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ASSOCIATION OF APHIDS OF THE GENUS PINEUS
WITH NEEDLE BLIGHT OF WESTERN WHITE PINE

Report of Preliminary Investigations
1959

Robert E. Denton, Entomologist

Prepared By The
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SUMMARY

Abnormal symptoms of crown deterioration, or needle blight, have reached serious proportions in western white pine stands in the Inland Empire. Preliminary investigations show that needle blight is a complex problem involving both fungi and insects; aphids of the genus Pineus are one of the suspected possible causes of needle blight.

Studies indicate that one species of Pineus in particular apparently is correlated with crown deterioration symptoms. The species has not yet been determined, but is distinguished by the scale-like appearance of the nymphs. This aphid not only is confined to the lower portions of tree crowns, where symptoms of needle blight become evident first, but it is more numerous on trees in advanced stages of crown deterioration.

Although preliminary data presented here are not considered conclusive, they do indicate a need for more detailed study of the role of Pineus in the needle blight complex. One fact is outstanding: data show that the number of aphids on a twig is not excessive, in the sense of being massed. This suggests that if aphids are responsible for needle blight of western white pine they must inject a toxin into the shoots or else they are carriers of a disease organism.

INTRODUCTION

Unexplained symptoms of crown deterioration have been observed periodically over the years in immature western white pine stands in the Inland Empire. These symptoms became conspicuous again in 1957; in 1958 they appeared over much of the western white pine type in northern Idaho, northeastern Washington, and northwestern Montana. The term "needle blight" is generally accepted in referring to crown deterioration symptoms.

The more obvious visual indications of needle blight are the death of 2-year-old or older foliage and the dying of branches beginning in the lower portions of tree crowns. In more advanced stages of deterioration only the upper third of the crown and the current growth at the tips of the lowermost living branches are still green (figure 1). Though little tree mortality has been reported yet, in 1959 the situation was aggravated by heavy infection of a needle cast disease on 1958 and 1957 foliage. It is questionable if the younger age classes can withstand many years of the combined effects of needle blight and the needle cast disease.

Although the appearance of blighted tree crowns suggests a disease problem, past observations implicate a species of aphid as a possible contributing factor. Because of these different possibilities preliminary investigations have been made by both entomologists and pathologists of the Intermountain Forest and Range Experiment Station. Results of the first observations in 1958 are published in a Station Research Note^{1/}.

A detailed description of needle blight symptoms and host tree damage is included in the publication. This report presents results of the 1959 investigations of the possible association of an aphid, Pineus sp., with needle blight.

^{1/} DENTON, R. E. and LEAPHART, C. D. 1959. Symptoms of abnormal crown deterioration in western white pine stands. Intermountain Forest and Range Experiment Station Research Note No. 69. Ogden, Utah.



Figure 1. Western white pine tree showing advanced symptoms of needle blight; Clarkia, Idaho (1959).



Figure 2. Photograph taken in 1911 at the Priest River Experiment Station. Western white pine tree in background appears to have characteristics of needle blight.

HISTORY

The earliest evidence of needle blight in this region is recorded in a photograph taken in 1911 at the Priest River Experiment Station, Idaho. In the background of the picture is a western white pine tree showing characteristics of crown deterioration (figure 2). Similar damage has been observed intermittently since that time. In 1935 Mr. Charles A. Wellner, now Chief, Division of Forest Management Research, Intermountain Forest and Range Experiment Station, photographed a western white pine sapling in the Priest River Experimental Forest showing advanced symptoms of crown deterioration (figure 3). His description on the photo record sheet reads "Western white pine tree after attack by aphids". Wellner recalls that he was impressed with the severity of needle blight again in 1939 and 1941 at the Priest River and Deception Creek Experimental Forests, and near Bovill, Idaho.

Another recent record was furnished by Dr. C. D. Leaphart, pathologist, Inland Empire Research Center, Spokane, Washington. He states that needle blight of western white pine was prevalent in 1950 on the Coeur d'Alene and Kaniksu National Forests, Idaho.

Records of the occurrence of Pineus are meager; no studies of this genus have been made in this region. Collections of aphids on western white pine in 1924 were identified as Pineus pinifoliae (Fitch) by Dr. P. N. Annand. Similar identifications were made by Dr. P. W. Mason of collections from western white pine in 1939 and 1942. Other collections of aphids in 1941 and 1942 from twigs of lodgepole pine were identified as Pineus coloradensis (Gill.) by Dr. Mason. No further collections of Pineus were made until 1959--this series has not yet been determined.

Only two instances of damage by P. pinifoliae are recorded. In 1937 the aphid reportedly caused serious damage to western white pine reproduction in Smith Creek, Kaniksu National Forest, Idaho. Again in 1939 similar damage occurred in a stand of reproduction near Noxon, Montana. Figures 4 and 5 illustrate the large number of aphids that were massed upon the twigs and the damage that occurred to branches. No comparable aphid populations have been encountered in current investigations.

The severity of needle blight in the past two years has caused considerable concern among foresters. In 1959 Potlatch Forests, Inc. retained Dr. C. Gardner Shaw, Washington State University, as a consulting pathologist to identify the pathological organisms associated with the dying and dead needles. Mr. Robert R. Baldwin of Potlatch's forestry staff was assigned to conduct aphid population measurements, assisted by entomologists of the Missoula Forest Insect Laboratory.



Figure 3. Photograph taken in 1935 of western white pine tree showing advanced symptoms of needle blight; Priest River Experimental Forest, Idaho.



Figure 4. Heavy infestation of Pineus on western white pine reproduction in 1937; Kaniksu National Forest, Idaho.



Figure 5. Damage to western white pine branch reportedly caused by Pineus in 1939; Noxon, Montana.

OBJECTIVES

The purpose of entomological observations in 1958 was to become acquainted with the needle blight complex and to determine the need for study of the possible association of aphids with the problem. Examinations of many western white pine stands throughout northern Idaho disclosed, almost invariably, the presence of Pineus sp. on current- and 1-year-old growth shoots. However, the possibility that aphids are responsible for needle blight was questioned because relatively few insects were found on the branches compared to records of heavy infestations mentioned previously (figure 4).

This year plans were made to delve deeper into the problem by determining whether aphid populations are correlated with needle blight symptoms. Three objectives were outlined: (1) To identify the species of aphids involved, (2) To devise a technique of measuring aphid populations, and (3) To determine whether there is any evidence of association between Pineus and the degree of crown deterioration.

SAMPLING PROCEDURES

Preliminary investigations were directed toward the problem of sampling and measuring aphid populations on new- and 1-year-old growth shoots of western white pine trees. Procedures were designed to measure the relative numbers of aphids (1) at different crown levels, (2) on trees showing varying degrees of crown deterioration from light to heavy, (3) on trees in areas free from needle blight, and (4) at different elevations within a drainage. Only the first two procedures were completed in 1959. No areas were located that were considered free from needle blight, and time did not permit measuring aphid populations at different elevations within a drainage.

The design of these sampling procedures was based upon two premises: Early visual symptoms of needle blight are dying foliage and branches at the base of a tree crown; if an aphid were responsible there should be a difference between the number of aphids in the lower crown compared to the number in the upper crown. Furthermore, differences in aphid numbers should be reflected by tree crowns varying in degree of crown deterioration. The following outline was prepared as a guide to collecting branch samples and measuring aphid populations:

OUTLINE OF APHID POPULATION SAMPLING

I. At Different Crown Levels

- A. Select and mark 5 trees (e.g., A1, A2, etc.) of convenient size for sampling (25' to 30') that are infested by aphids. A check of several branch tips will indicate an existing population. These trees do not have to be correlated with any degree of crown deterioration.
- B. Record D.B.H. and height of each tree and describe the crown characteristics, symptoms of deterioration, amount of needle retention, etc.
- C. At each of 3 crown levels (lower, middle, and upper thirds) cut 3 branch tips from around the circumference of the crown.
- D. Select the terminal growth shoot on each branch tip and record its length and the number of living nymphs and adults. This will give a total of 15 measurements at each of 3 crown levels. Express the population as the number of aphids per linear inch of terminal shoot.
- E. Test the data for significant differences in aphid populations between trees and crown levels.
- F. If possible make supplementary observations on mature trees, similar to those listed above, by visiting current logging operations and sampling felled trees.

II. On Trees Of Varying Degrees of Crown Deterioration

- A. Select and mark 10 trees in each of 3 categories of crown deterioration: light, moderate, and heavy. Record D.B.H. and height of each tree and describe the crown characteristics, symptoms of deterioration, amount of needle retention, etc.
- B. Cut 3 branch tips in the lower third of the crown of each tree.
- C. Select the terminal growth shoot on each branch tip; record its length and the number of living nymphs and adults of the "scale-type" aphid. This will give a total of 30 measurements for each crown deterioration class.

- D. Repeat these measurements on the 1-year-old growth portions of the twigs.
- E. Analyze the data for significant differences in aphid populations between the several degrees of crown deterioration.

III. On Trees In Areas Free From Needle Blight

- A. If areas are located that are free from crown deterioration symptoms, establish one or more plots of 10 trees each within the areas.
- B. Proceed with the measurements described in the preceding section.

IV. At Different Elevations Within A Drainage

- A. It has been suggested that the degree of crown deterioration is more severe at the bottom of a drainage than it is higher up the slope. To determine whether there is a correlation between differences in elevation and numbers of aphids, select 10 trees for sampling at intervals extending from the bottom of a drainage up the slope to the ridge-top.
- B. Proceed with the measurements described in the foregoing section.

RESULTS

IDENTITY OF APHIDS INVOLVED

Superficial observations in 1958 indicated that Pineus is distributed throughout the length of western white pine tree crowns; this accounted in part for a belief that the aphid was not connected with needle blight, since blight symptoms originate at the base of the tree crown. In 1959 closer examination of aphid specimens collected in the upper crown revealed differences when compared to individuals in the lower crown. Some of the characteristics that follow are considered tentative until they are confirmed by more detailed study of the aphids.

The species of Pineus involved in the needle blight complex have not been definitely separated. Slide mounts are being prepared for the determination of a series of aphids in question. The main difference between those in the lower and upper crown is that the immature stage of the one in the lower crown is scale-like in appearance (flattened, ovoid, with the legs folded under the body), unlike the adult, whereas in the upper crown the nymphs are soft-bodied, rounded, and closely resemble the adult. Other characteristics distinguishing the aphid in the upper crown are (1) the majority are found in the top third of the crown, often clustered at the apical tip of new growth shoots; very few of the scale-like form were found above the middle third of the crown, (2) more copious wax production by nymphs and adult females, (3) the crawler stage, or first nymphal instar, appears more agile, (4) fewer eggs are laid per female, and (5) apparently there is more than one generation a year; the scale-like type in the lower crown appears to have only one generation each year.

APHID POPULATIONS BY CROWN LEVELS

Five western white pine trees, about 25 feet in height, were sampled to determine the distribution of aphids within the tree crown. The trees showed few symptoms of crown deterioration at the time of examination in July, though needle blight is prevalent in the general vicinity. Living nymphs and adults were counted on 1959 terminal growth shoots of 3 samples from each of the upper, middle, and lower crowns.

Results of the population sampling are summarized by crown levels in table 1. Data from which this table is compiled are included in Appendix table 1.

Table 1.--Summary of aphid population measurements by crown levels; Fry Creek, Bovill, Idaho

Tree no.	Av. no. aphids per linear inch of 1959 growth terminal		
	Upper crown	Middle crown	Lower crown
A1	0.9	0.5	10.0
A2	2.6	1.6	3.6
A3	2.3	0.7	1.6
A4	2.7	0.8	0.6
A5	0.9	0.6	3.5
Average	1.9	0.9	3.9

Results of this phase of the investigations reveal that: (1) Aphids are found on current year growth shoots throughout the length of western white pine tree crowns; however, those in the upper crown appear to be a different species than those in the lower crown, and (2) based upon the 5 trees sampled there is an arithmetical average of twice as many aphids in the lower crown compared to the upper crown.

Examination of the data for individual trees shows that the arithmetical average of aphid numbers in the lower crown is misleading. When these data were analyzed for variance the following conclusions were reached:

1. There is no significant difference in aphid numbers between the lower and upper crown.
2. Aphid numbers are significantly lower in the middle portion of the crown compared to the upper and lower crown.

The important point is that the scale-like aphid form is confined mostly to the lower portions of western white pine tree crowns; practically no scale-type was found in the upper crown. This fact suggests a possible correlation between this aphid and symptoms of crown deterioration.

APHID POPULATIONS AND DEGREE OF CROWN DETERIORATION

Aphid populations were measured on 10 trees in each of 3 crown deterioration classes--light, moderate, and heavy. Sampling was restricted to the lower third of the crown and only scale-type aphids were counted to avoid confusion with the other aphid type in the upper crown. Three branch samples were cut from each tree; aphid populations were measured on both the 1959 and 1958 growth portions of the twigs.

A summary of the results is presented in table 2. Complete data from which this table is compiled are found in Appendix tables II, III, and IV.

Table 2.--Comparison of aphid populations and degree of crown deterioration

<u>Degree of crown deterioration</u>	<u>Av. no. aphids per linear-inch of growth shoot</u>	
	<u>1958</u>	<u>1959</u>
Light	0.7	0.4
Moderate	0.6	0.3
Heavy	2.4	5.5

These data show a significantly greater number of aphids associated with heavy crown deterioration symptoms compared to light and moderate crown deterioration symptoms.

DISCUSSION

Preliminary investigations show that needle blight of western white pine is a complex problem that may prove difficult to resolve; both fungi and insects seem to be involved. In 1959 the problem was confounded further by (1) the sudden, widespread appearance of a needle cast disease on 1958 and 1957 foliage, and (2) discovery that more than one species of Pineus may be present in the tree crowns. Despite this confusion considerable progress has been made in gaining an understanding of the entomological aspects of the problem. The way is clear to plan a detailed study of the aphid's role in the needle-blight complex if conditions warrant it.

Data presented in this report are not considered conclusive. Refinements in sampling techniques as well as increasing the scope of sampling to include other areas and conditions might alter the picture considerably. One important phase of future investigations is to determine the status of the aphid in blight-free stands of western white pine.

Difficulty was encountered in classifying trees according to the degree of crown deterioration, especially in the light and moderate severity classes. The reason for this is that the several symptoms of needle blight are not consistently found together, nor in the same proportions on different trees. Following are the characteristics that were used to classify the degree of crown deterioration, listed in order of decreasing importance:

1. Needle retention, lower crown
2. Needle retention, middle crown
3. Needle retention, upper crown
4. Miscellaneous characteristics
 - a. Growth rate of stems; needle length
 - b. Abnormal retention of dead needles
 - c. Browning of portions of needles

The difficulty of classifying the severity of crown deterioration might account in part for the fact that almost no difference in aphid numbers was found between light and moderate classifications (table 2). In this respect, it is hard to conceive that populations on 1959 and 1958 growth shoots averaging 0.5 aphids per linear inch could be responsible for causing needle blight.

Another point to consider is that many branch samples showed symptoms of needle blight, but no aphids were found on the shoots-- at least at the time of examination in late August. These facts suggest that if aphids are responsible for needle blight they must either inject a toxin into the shoot or else they are carriers of a disease organism.

RESEARCH POSSIBILITIES

The results of preliminary investigations do not absolve aphids from the crown deterioration problem; rather, they indicate the need for additional study to determine specifically whether Pineus is capable of producing symptoms of needle blight. Several lines of endeavor have been suggested:

1. Continued study of the biology of Pineus species involved in the problem.
2. Studies designed to exclude the aphid to determine if needle-blight symptoms develop without its presence.
3. Studies designed to infest healthy branches to determine the possible development of needle-blight symptoms.

If it were found that Pineus is capable of causing needle blight of western white pine, the remaining problem would be to determine its exact role in killing foliage and branches.

APPENDIX

Table 1. *Pineus* sp. population measurements by crown levels; Fry Creek, Bovill, Idaho, July 1959

Tree no.	Crown third sampled	Length of 1959 growth shoot (inches)	Number aphids counted			No. aphids per linear inch of growth shoot	Av. no. aphids per linear inch
			Adults	Nymphs	Total		
A1	Upper	8.3	0	0	0	0.0	0.9
		7.9	2	5	7	0.9	
		5.4	2	8	10	1.9	
	Middle	5.0	0	5	5	1.0	0.5
		7.5	0	0	0	0.0	
		5.8	1	1	2	0.4	
	Lower	1.8	1	30	31	17.2	10.0
		2.8	6	27	33	11.8	
		3.4	0	4	4	1.2	
A2	Upper	5.9	11	2	13	2.2	2.6
		7.9	17	3	20	2.5	
		4.9	14	2	16	3.3	
	Middle	5.4	2	1	3	0.6	1.6
		7.4	5	1	6	0.8	
		4.4	10	5	15	3.4	
	Lower	2.8	0	9	9	3.2	3.6
		3.1	1	7	8	2.6	
		3.0	4	11	15	5.0	
A3	Upper	13.8	44	12	56	4.1	2.3
		9.4	11	3	14	1.5	
		10.0	9	3	12	1.2	
	Middle	9.7	2	3	5	0.5	.7
		6.3	5	3	8	1.3	
		7.8	0	3	3	0.4	
	Lower	5.2	2	5	7	1.3	1.6
		5.0	0	2	2	0.4	
		4.1	0	13	13	3.2	
A4	Upper	15.8	20	18	38	2.4	2.7
		16.5	25	11	36	2.2	
		11.3	30	10	40	3.5	
	Middle	5.7	5	2	7	1.2	.8
		5.4	3	1	4	0.7	
		8.6	3	1	4	0.5	
	Lower	4.4	3	3	6	1.4	.6
		3.1	0	0	0	0.0	
		2.4	0	1	1	0.4	
A5	Upper	15.4	6	7	13	0.8	.9
		13.4	7	8	15	1.1	
		15.6	5	7	12	0.8	
	Middle	12.4	11	6	17	1.4	.6
		10.2	0	0	0	0.0	
		7.4	1	1	2	0.3	
	Lower	2.9	1	16	17	5.9	3.5
		4.6	3	14	17	3.7	
		5.6	2	3	5	0.9	

Table II. Pineus sp. population measurements on trees with light crown deterioration, Pierce, Idaho; August 1959

Tree no.	Side of crown sampled	Length of growth shoot (Inches)		Total no. aphids of scale-type		Av. no. aphids per linear inch	
		1958	1959	1958	1959	1958	1959
1	North	3.1	2.1	0	0		
	East	2.9	2.3	3	6	0.3	0.9
	West	3.7	2.5	0	0		
9	North	2.8	2.6	0	4		
	East	2.0	2.7	0	0	0.3	0.9
	West	2.4	2.7	2	3		
19	North	3.5	2.9	0	0		
	East	3.4	3.3	0	0	0.0	0.0
	West	3.6	3.5	0	0		
22	North	5.7	6.0	0	0		
	East	6.8	6.7	0	0	0.4	0.0
	West	6.2	5.5	8	0		
24	North	5.8	4.5	0	0		
	East	4.8	4.1	0	0	0.0	0.0
	West	6.7	4.8	0	0		
25	North	4.9	4.5	10	0		
	East	3.5	4.1	8	1	1.2	0.1
	West	6.6	4.8	0	0		
26	North	1.8	1.6	9	10		
	East	3.5	3.7	19	4	3.0	2.0
	West	5.4	3.6	4	4		
27	North	2.7	2.7	0	1		
	East	3.0	2.7	0	0	0.0	0.1
	West	4.1	4.6	0	0		
29	North	5.8	6.4	0	0		
	East	6.6	5.3	25	1	1.5	0.05
	West	5.0	5.5	1	0		
30	North	4.8	5.6	0	0		
	East	3.8	3.7	0	1	0.0	0.1
	West	5.2	2.8	0	0		

Table III. Pineus sp. population measurements on trees with moderate crown deterioration, Pierce, Idaho; August 1959

Tree no.	Side of crown sampled	Length of growth shoot (inches)		Total no. aphids of scale-type		Av. no. aphids per linear inch	
		1958	1959	1958	1959	1958	1959
3	North	4.2	4.0	0	0	0.0	0.4
	East	4.3	4.3	0	0		
	West	2.4	2.0	0	4		
7	North	3.8	2.3	0	0	0.0	0.0
	East	4.3	3.5	0	0		
	West	4.3	3.9	0	0		
8	North	3.1	2.9	15	5	3.3	1.0
	East	3.2	3.0	9	1		
	West	4.2	3.0	10	3		
11	North	3.1	1.7	6	2	0.9	0.5
	East	3.1	2.0	2	1		
	West	3.0	1.8	0	0		
12	North	3.8	3.6	7	2	1.2	0.3
	East	3.6	2.6	5	1		
	West	4.1	3.8	2	0		
13	North	3.3	3.2	0	0	0.0	0.0
	East	3.1	3.0	0	0		
	West	3.6	3.7	0	0		
18	North	3.6	3.2	0	0	0.0	0.0
	East	3.8	3.3	0	0		
	West	4.1	4.1	0	0		
20	North	4.9	3.9	0	0	0.0	0.0
	East	4.2	3.1	0	0		
	West	4.6	3.2	0	0		
21	North	5.2	3.7	0	0	0.4	0.7
	East	3.7	3.0	1	3		
	West	4.6	4.0	5	4		
23	North	8.4	6.4	1	0	0.2	0.1
	East	6.1	4.2	2	0		
	West	5.1	3.4	1	1		

Table IV. *Pineus* sp. population measurements on trees with heavy crown deterioration, Pierce, Idaho; August 1959

Tree no.	Side of crown sampled	Length of growth shoot (inches)		Total no. aphids of scale-type		Av. no. aphids per linear inch	
		1958	1959	1958	1959	1958	1959
2	North	3.4	1.8	9	9	3.6	7.5
	East	2.4	1.7	18	15		
	West	2.3	1.6	2	14		
4	North	2.2	1.6	1	0	0.3	3.5
	East	1.6	1.3	1	4		
	West	2.1	1.2	0	0		
5	North	1.5	0.9	0	8	2.6	12.9
	East	2.1	1.1	4	21		
	West	3.0	1.4	13	15		
6	North	4.5	4.1	6	0	0.6	0.0
	East	3.8	3.6	1	0		
	West	3.7	2.2	0	0		
10	North	1.7	1.0	5	11	1.4	5.1
	East	3.2	2.0	1	0		
	West	0.9	0.5	2	7		
14	North	1.3	0.8	17	11	3.6	14.8
	East	1.2	0.9	8	7		
	West	1.0	0.6	5	16		
15	North	3.0	2.1	1	0	0.8	1.4
	East	2.1	1.2	0	1		
	West	2.0	1.7	5	6		
16	North	1.3	1.0	8	8	2.7	4.9
	East	2.1	1.5	1	2		
	West	1.1	1.0	3	7		
17	North	2.3	1.6	7	7	3.1	4.5
	East	1.6	1.1	6	7		
	West	1.2	1.1	3	3		
28	North	5.2	3.1	1	0	0.1	0.0
	East	4.0	2.4	0	0		
	West	4.8	3.4	0	0		